Chemical Education Research

edited by
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Warrensburg, MO 64093

How Long Can Students Pay Attention in Class? A Study of Student Attention Decline Using Clickers

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A common experience among teachers is that students do not pay attention throughout an entire lecture. From the front of the lecture hall, the teacher can often see individual students drifting off, staring into space, checking their text messages, or doing homework for another course. Some of the more successful teachers are able to hold students' attention by making their classes more interactive. One of the innovative methods used to engage students in class is the use of individual response devices (clickers) that enable students to respond to teacher questions by sending their answers electronically to the teacher's computer. The teacher can then display for the class the percentage of students that responded to each answer in a multiple-choice question while keeping individual responses anonymous. Other teachers use engaging demonstrations to capture student interest in the concept at hand. These are but two of the more common student-centered approaches used in class to help keep students focused on the content.

Background

The question remains, how long do students pay attention in lecture before their attention declines? Although it seems as if there should be a database of research to address this question, the truth is that there are some commonly held beliefs but little classroom-based research to support them. McKeachie *(1)*, in his often-recommended book on tips for lecturers, suggests that student attention will drift during a passive lecture unless interactive strategies are used to hold student attention. He suggests breaking up long class lectures with interactive strategies. McKeachie's advice is corroborated by other authors *(2)*. Bligh *(3)*, in his book about how to lecture, advises that students are not likely to pay close attention to a lecture in the first 5 min while they are settling down nor during the last 5 min when their attention rises and falls. Sousa *(4)* suggests that students' processing of information during lecture is dependent upon their motivation. The more motivated students pay attention longer than the less motivated. He suggests that unmotivated students pay attention for an average of 10−20 min. This means that a teacher may see the beginning effects of attention decline after 10 min of lecturing. Sousa suggests that lectures be broken up into 15−20 min segments to address this problem.

Johnstone and Percival *(5)* conducted one of the few classroom studies to measure student attention during lecture. The methodology included having observers in the lecture hall who sat facing the students and recorded breaks in student attention through observations of the students themselves. The results of this study include observable lapses in student attention that lasted 2−4 min occurring during the first 5 min of lecture while students were settling down, 10−18 min later, and more frequently as the lecture proceeded beyond that. Attention lapses by the end of lecture occurred approximately every 3−4 min. Johnstone and Percival recommend interspersing a lecture with breaks or different teaching approaches as a way to maintain student attention.

Investigations Conducted in This Study

Question 1—Reporting Attention Lapses

The literature raises the question of how long students pay attention during the lecture segment of a class. This study investigated this idea by measuring how often during a lecture segment students report a lapse in their attention. Because students were reporting multiple times during a lecture segment, a repeated measures analysis was chosen to analyze this data. This particular statistical analysis was used to investigate whether or not a significant difference in self-reported attention decline occurs during an entire lecture segment. It does not provide information on what time in a lecture segment a significant difference in the number of self-reported student attention lapses occurs.

Question 2—Identifying the Length of Attention Lapses

In this study, attention lapses during a lecture segment were reported by students as short, medium, or long through their choice of specific buttons on the clicker. It was hypothesized that students would report short attention lapses more often than longer ones during a lecture segment.

Question 3—Possible Influences of Pedagogy on Attention Lapses

Possible differential student attention during student-centered pedagogies versus lecture was investigated. The pedagogies selected were those typically used on a regular basis by the teachers in this study. A second requirement for inclusion of specific pedagogies was that the length of the pedagogy had to be comparable to that of a typical lecture segment used in this study. It was hypothesized that if student attention changed significantly during a student-centered pedagogy compared to the preceding lecture segment, this change might affect student attention in a successive lecture segment.

Methodology

The limitations of this study include the fact that student participation was voluntary and no option was available for students to indicate that they were actually engaged in learning. The methodology used here, therefore, measures only voluntary,

10.1021/ed100409p Published on Web 10/22/2010

self-reported lapses of attention and the analysis is restricted to documented changes in the students who chose to report lapses of attention.

Operational definitions are provided for key terms used in this study:

- *Lecture*: Traditional pedagogical approach involving the teacher presenting information to an audience. The flow of information proceeds from the teacher to the student.
- *Lecture segment*: Length of time devoted to lecture pedagogy.
- *Demonstration*: Use of chemicals or models to present a visual experience of the chemistry concept being presented.
- *Clicker question*: ConcepTest *(6)* presented electronically through the use of personal response devices. (Turning Technologies individual response devices were used in this study.)
- *Class*: Full length of the teaching session. In this study, all classes had durations of 50 min.
- *Course*: Semester-long curricula that for this research included General Chemistry for engineering students (Chem I); General, Organic, and Biochemistry for nursing students (Chem II); and Chemistry in Context, general chemistry for nonscience majors (Chem III).
- *Pedagogical approach*: Any presentation or interaction between teacher and student during a class. Typical examples include lecture, demonstration, clicker questions, and so forth.

Sample

The study was conducted in the Fall 2008 semester at a medium-sized private university in the District of Columbia. The students who participated in this study were enrolled in one of three chemistry courses: General Chemistry for engineering students (Chem I, n = 74, taught by Instructor A); General, Organic, and Biochemistry for nursing students (Chem II, n = 68, taught by Instructor B); and Chemistry in Context, general chemistry for nonscience majors (Chem III, n = 44, also taught by Instructor B). These courses were selected to represent a diverse population of introductory chemistry students and content.

Procedure

Each student used a clicker *(7)* to participate in the study. These devices transmitted responses on self-reported attention declines to a radio frequency receiver connected to the researchers' tablet PC at the back of the classroom. Students enrolled in Instructor A's course (Chem I), where clickers had not been previously used, selected a clicker attached to a lanyard at random each day. As a result, students in this course could not be tracked individually during the study. Students enrolled in both of Instructor B's courses (Chem II and Chem III), where clickers were used regularly as part of the daily instruction, were tracked according to a specific clicker number that remained constant during the experiment. These students (Chem II and Chem III) used two clickers: their own clicker that they brought to class each day for the clicker questions used in class, and a second clicker distributed at the beginning of each class worn on a lanyard around their necks to record attention lapses.

Students were instructed to press one of three buttons on the lanyard clicker (to view Turning Technologies personal response devices, go the Website, http://www.turningtechnologies.com/audienceresponseproducts/responseoptions/) representing varying lengths of time when their minds wandered from the material being presented in class. Button 1 was used for a lapse of attention of 1 min or less such as looking at the clock or reading a text message; Button 2 for a 2-3 min lapse such as responding to a text message; and Button 3 for a lapse of 5 min or more such as working on homework for another course. Students' responses were recorded electronically every 30 s during the 50 min class on the researchers' tablet PC in the back of the room. Students reported lapses in attention only after they realized their attention had wandered. As a result, the student data collected in this study represent times immediately following the occurrence of attention lapses, not the lapses themselves.

Students in this study were reminded to use their clickers daily, either informally when they picked them up or formally through a reminder at the bottom of the instructor's lecture slides.

Prior to the beginning of the research, 14 different pedagogical approaches were identified including: lecture, demonstration, clicker questions, working in student groups or pairs, inclusion of real-world applications, personal vignettes, and announcements. Each time the teacher used a different pedagogical approach, regardless of the length, the researcher recorded it on the screen of the same tablet PC used to collect student clicker responses. The three most common pedagogies used by the teachers in this study (lecture, demonstration, and clicker question) were chosen for further investigation.

Data Collection

Data were collected for 6 weeks in each of the three courses. The initial 2 weeks' data were used for student practice with the clicker technology and determination of inter-rater reliability among the researchers in regards to the start and stop of new teaching pedagogies. Inter-rater reliability was based on raters' accurately identifying and recording changes in pedagogical approaches. Once an acceptable inter-rater reliability was attained, data were collected for analysis. The 2-week practice with the technology proved adequate for establishing inter-rater reliability at an acceptable level.

Student participation varied by day and course. In Chem I (chemistry for engineering majors) taught by Instructor A, on average 23% of the students enrolled in the course participated in the study each day by using their clickers. Over the 4 weeks of the experiment, the percentage of unique individuals who participated at least once may have been different from the daily average, but this could not be determined because students did not use clickers in class other than to record occurrences of attention decline and therefore were issued clickers randomly each day. This resulted in not being able to track the participation of unique individuals for this course. In Chem II (chemistry for nursing majors) and Chem III (chemistry for nonscience majors), taught by Instructor B and in which clickers were used by students regularly in class, unique individual responses could be tracked. The average participation each day over the entire 4 weeks of the study was 56% (Chem II) and 27% (Chem III). The number of unique individuals who participated in the study in these two classes at least once during the study was higher: 79% (Chem II) and 54% (Chem III). Table 1 summarizes these results.

These results show that, although the average daily participation was 56% or lower, the number of students who participated at least once during the study was higher in the two courses where it could be measured, demonstrating that the technique of recording lapses of attention was at least accessible to a larger number of students.

Table 1. Percentage of Students Who Participated on a Daily and an Average Basis

Treatment Groups	Participation by Course, %		
	Chem I (n = 74)	Chem II (n = 68)	Chem III (n = 44)
Average % of students who participated each day	23	56	27
Unique individuals (%) who participated at least once during the study	Unknown[a]	79	54

[a] Cannot be determined because students were not assigned a specific clicker each day.

Table 2. Comparison of Lecture Lengths by Course

Course	Common Lecture Length, Min
Chem I	12
Chem II	12
Chem III	9.5

Analysis and Conclusion

The following analysis is restricted to the data provided by the voluntary participation of students in this study. The conclusions reported are an initial attempt to experimentally measure how long students pay attention in class.

Question 1—Analyzing the Number and Timing of Student-Reported Attention Lapses

To address the first question regarding how often during a lecture segment students report a lapse in their attention, a repeated-measures ANOVA was used. To use this statistic, the data were examined for compliance with the following requirements: independence of observations, normal distribution of data, and homogeneity of variance *(8)*. This statistic requires that the lecture segments compared within a course be of a common length or shorter. Thus, only lecture segments equal to or shorter than the common length established from the data collected within each course were analyzed in this study. The common length of lecture for each of the three courses was not necessarily the same. Common lengths of lecture were the longest uninterrupted lecture segments that occurred repeatedly within a specific course. A class that included a lecture with a demonstration and then more lecture would be classified as having three segments: two lecture segments and one demonstration segment. Common length lecture segments could occur at any point during the class (beginning, middle, or end). An average of 40 lecture segments of common length was used in the analysis for each course. Lecture segments above the common length were not included in the analysis of Question 1. Table 2 presents the common lecture segment length for each course.

For analysis of Question 1, each student response was counted as a single "click" regardless of the button pressed (Button 1 for short, Button 2 for medium, and Button 3 for long). The clicks recorded in each 30-s interval across all classes within a course over the 4 weeks of the study were compiled. This compilation of student clicks at a particular point in time within the common length lecture segment per course was necessary for

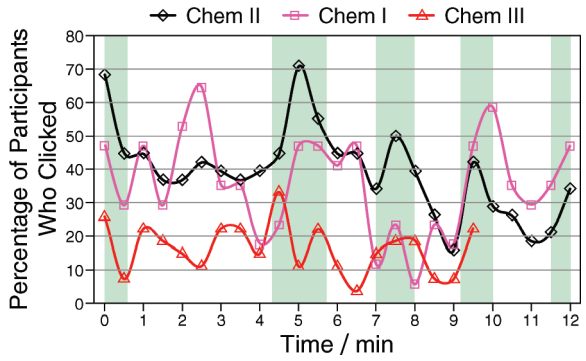

Figure 1. Common declines of attention in lecture reported over time for three courses.

the statistical comparison. For instance, at minute 2, the mean number of student clicks for this time across all common length lecture segments in all classes within a course during the 4 weeks of data collection is reported. This was done separately for the three courses (Chem I, II, and III). A repeated-measures ANOVA was used to analyze the difference in means of student-reported attention lapses (clicks) at each measured point in time during a common length lecture segment per course. The ANOVA tests for the presence of a significant difference in the number of clicks during the time of the lecture segments, but because of the large number of repeated measures, it is not possible to identify at which time point the comparison is significant. For instance, in Chem II whose common lecture segment is 12 min, there are 24 measurements at 30-s intervals. Analysis of each of these 24 time intervals would result in over 300 comparisons, leading to an unacceptable threat of Type I error. Instead, the statistic provides only a measure of global significance of the difference in the number of clicks over the entire common lecture segment per course. Consequently, a significant difference in the number of student-reported attention lapses (clicks) that occurred somewhere during the length of compiled lectures per course is reported. The strength of this analysis is the investigation of an overall significant difference based on a large number of data points.

Analysis of the number of student-reported attention lapses during common length lecture segments per course resulted in significant differences for Chem II only, with F (19, 1313) = 1.60, p = 0.047. Chem II is the course with the greatest daily average student participation, 56%. The other two courses showed no significant effect due to time: Chem I, F (26, 2863) = 1.22, p = 0.205; Chem III, F (9, 641) = 0.86, p = 0.571.

In Figure 1, student clicks are represented as a percentage of participating students (not as a percentage of the total number of students in the course) who reported an attention decline at each time interval. Each point in the graph does not necessarily include self-reports by the same students. Instead, it is a compilation of all students at that point in time in a particular course over the 4 weeks of the experiment. The graph shows the cyclic nature of the occurrence of student-reported attention lapses for Chem II represented by the diamond line. The data from the other two courses where student participation was lower than in Chem II were added to the figure to show an overall trend. It is possible that, with additional participation of students, this common trend exhibited in Chem I and Chem III might also prove statistically significant. Although the three courses differed

Table 3. Comparison of Short, Medium, and Long Lapses of Attention for Chem II

Attention Lapse Duration	Mean during Lecture (Number of Clicks/30 s)	*F* (df = 4, 324)	Significance
Button 1: 1 min or less	3.34	8.30	0.000
Button 2: 2−3 min	1.06		
Button 3: 5 min or more	0.44		

in the common length of their lecture segments used in this analysis (Table 2), data from all 40 lectures in each of the three courses were included in Figure 1 for comparison. For instance, the length of the common lecture segments in Chem III is shorter than that of Chem I and II.

To help interpret the trend in student self-reported attention lapses for the significant result in Chem II and the similar nonsignificant results in Chem I and Chem III, shaded boxes have been overlaid on the graph. The time intervals represented by these boxes demonstrate a similarity in peaks of student-reported attention lapses across all three courses. For instance, a peak in attention lapse is reported for Chem II in the 4.5−5.5 min time interval. Peaks are also visible for Chem I and Chem III during this same interval. Similar trends can be found at intervals of 7−8 min, 9−10 min, and during both the initial and final 30 s as represented on the graph. Variation exists among the classes in the time between these identified intervals, but the interval trend suggests a common time frame for peaks in student attention lapses both in the statistically significant and nonsignificant data.

Question 2—Identifying the Length of Attention Lapses

To investigate the second question regarding the length of attention lapses reported by students, only data from Chem II (nursing majors) were used in the analysis because this was the only class that showed a significant change in student-reported attention lapses over time. Length of attention decline was recorded by students through their selection of Button 1 (1 min or less), Button 2 (2−3 min), or Button 3 (5 min or more) on the clickers. An ANOVA was used to compare the means of the three choices of attention lapse length in Chem II. As reported previously, all required assumptions for using an ANOVA were met by the data for this analysis. The results of the statistical analysis as shown in Table 3 indicate that the shortest attention lapse (1 min or less) as reported by students selecting Button 1 on their clickers was significantly more prevalent than the other two lengths (2−3 and 5 min or more) for Chem II. These data indicate that student-reported attention decline occasions for Chem II are primarily of short duration (1 min or less).

Question 3—Analyzing Attention Lapses Relative to Student-Centered Pedagogies

To address Question 3, an investigation of differential student attention during student-centered pedagogies (demonstrations and clicker questions) was compared to that of comparable lecture segments. The lecture segments used in this analysis had to match the length of the student-centered pedagogies as required by the statistic chosen. The two student-centered pedagogies investigated were the use of demonstrations and clicker questions. Because the average duration of both of these pedagogies was 5 min, the only lecture segments that could be compared to them were lecture segments of 5 min.

Table 4. Distribution of Pedagogies Used in Each Course

Course	Lecture	Clicker Questions	Demonstrations
Chem I	X		X
Chem II	X	X	
Chem III	X	X	X

In Chem I, Instructor A used demonstrations, but not clicker questions, repeatedly; in Chem II, Instructor B regularly employed clicker questions, but not demonstrations. In Chem III, Instructor B used both clicker questions and demonstrations. See Table 4.

In the analysis comparing student-centered pedagogies (clicker questions and demonstrations) versus lecture segments, all required assumptions for the ANOVA were met by the data. The ANOVA analysis compared the means of student-reported attention lapses for clicker questions versus lecture segments of equal length for each of the two courses (Chem II and III) that employed both clicker questions and lecture to determine significance. The data reported in Table 5 show that, in both courses (Chem II and III), the effect of the clicker pedagogy was significant, with students reporting significantly fewer attention lapses during the use of clicker questions than lecture segments of comparable length.

Differences in student-reported attention lapses for demonstrations versus lecture segments were analyzed for Chem I and Chem III only. These were the courses in which demonstrations were used regularly by both instructors. The results reported in Table 5 show that students report significantly fewer attention lapses during demonstration (0.026 for Chem I and 0.007 for Chem III) versus lecture segments (0.060 for Chem I and 0.017 for Chem III) of comparable length. The ANOVA was used to analyze the means of student-reported attention lapses for demonstrations (Chem I and II) versus lecture segments for each of these two courses to determine significance. Table 5 shows that in both courses the student-reported attention lapses were significantly lower during demonstrations than in lecture segments. The effect of clicker questions versus demonstrations could not be analyzed owing to the assumption required by the statistic that both pedagogies would have to have been executed on the same day in the same class. This did not occur in this study.

To address the question of whether the occurrence of a student-centered pedagogy positively affects student attention in a subsequent lecture segment, an ANOVA was used to analyze the means of student-reported attention lapses in the common length lecture segment prior to the student-centered pedagogy (clicker question or demonstration) versus the lecture segment following these pedagogies. All required assumptions for the use of an ANOVA were met by the data for this analysis. The analysis showed that, with clicker use, a significant difference emerged between the lectures before and after clicker questions for Chem II, with significantly fewer attention lapses reported for lecture segments following clicker questions. (See Table 6.) In Chem III, which had fewer students participating, no significant difference was found between the pre- and postclicker question lecture segments.

Table 5. Mean Numbers of Clicks for Lecture versus Clicker Questions and Demonstrations

Course	Lecture Mean (Number of Clicks/30 s)	Clicker Question Mean (Number of clicks/30 s)	Demonstration Mean (Number of clicks/30 s)	*F*	Significance
Chem II	0.030	0.013	—	26.71[b]	0.000
Chem III[a]	0.006	0.002	—	6.93[c]	0.011
Chem I	0.060	—	0.026	7.22[d]	0.009
Chem III[a]	0.017	—	0.007	5.46[e]	0.022

[a] Chem III was the only course that included both clickers and demonstration. This course was included in two analyses with separate means for each pedagogy that was used. [b] df = 1, 67. [c] df = 1, 67. [d] df = 1, 86. [e] df = 1, 67.

Table 6. Change in Number of Clicks for Lectures Occurring before versus after Student-Centered Pedagogies

Course (Pedagogy)	Lecture before Pedagogy, Mean Number of Clicks/30 s	Lecture after Pedagogy, Mean Number of Clicks/30 s	*F* (df)	Significance
Chem II (Clicker Question)	0.015	0.009	8.70 (1, 66)	0.004
Chem III (Demo)	0.028	0.013	4.25 (1, 64)	0.043

In Chem I, in which Instructor A frequently used demonstrations, a significant decrease occurred in the number of student-reported attention lapses in the lecture segments following a demonstration compared to those during lecture segments preceding the demonstrations. (See Table 6.) In Chem III with its lower student participation, no significant difference was found in lecture segments occurring before and after demonstrations.

These results indicate that students may be able to pay more attention during lecture segments that follow the implementation of a student-centered pedagogical approach than those lecture segments prior to the pedagogy. This result, together with the previous result that students pay more attention during the student-centered pedagogies of clicker questions and demonstration, suggests that interspersing a lecture with more student-centered pedagogies may increase student attention both during the actual pedagogy and during a subsequent lecture.

Summary

This research represents a unique use of technology (personal response devices, clickers) as both a pedagogical and a nonconspicuous research tool. As opposed to previous research *(5)* in which researchers faced the class to record observations of attention based upon students' facial expressions, this study had students register their awareness that their attention had declined during a class without the researchers interrupting or being obtrusive to collect data. Clickers appear to be a convenient way to survey students during class without significantly interrupting the flow of the class.

Contrary to common belief *(3, 4)*, the data in this study suggest that students do not pay attention continuously for 10−20 min during a lecture. Instead, their attention alternates between being engaged and nonengaged in ever-shortening cycles throughout a lecture segment. Although the pattern can be affected by specific teachers and courses, there remains some similarity among student attention patterns across different teachers and courses as reported here. Students report attention lapses as early as the first 30 s of a lecture, with the next lapse occurring approximately 4.5 min into a lecture and again at shorter and shorter cycles throughout the lecture segment. These results challenge part of the work of Johnstone and Percival *(5)* who observed student inattention occurring 15 min (beginning 5 min plus 10 min) into a lecture, but these results do support the observation *(5)* that student attention lapses occur in ever-shortening cycles as the lecture proceeds.

As many predict, student attention is higher during non-lecture pedagogies such as demonstrations and clicker questions. This was verified by the significantly lower number of self-reported student attention decline occasions during the 5-min duration of either a demonstration or clicker question. Equally important are the data that show that students report significantly lower attention lapses during lecture segments immediately following a demonstration or clicker question than they did in comparable length lecture segments prior to the use of these pedagogies.

Interestingly, students report short lapses of attention of 1 min or less significantly more often than either medium (2−3 min) or long (5 min or more) lapses. This is one of few studies in which participants had an option to report the length of their perceived attention lapse. These data may serve as an indication that students are trying to pay attention by reengaging after they realize that their minds have wandered during a lecture segment. With help from the teacher in terms of interspersing lecture with student-centered pedagogies, the amount of time that students pay attention in class may be increased.

Implications for Teaching

The advice to teachers based upon the experimental evidence of this study is that students do not pay attention continuously during a 50-min lecture. Teachers should be aware of student attention cycles within a lecture and strive to improve student attention by using student-centered pedagogies at different times throughout a lecture, not only to decrease student attention lapses but also to increase student attention during the lectures that follow the use of such pedagogies. This research demonstrates that the positive effect of student-centered pedagogies does more than decrease student inattention during their duration but also has the added benefit of a carryover effect to a subsequent lecture segment. This supports the idea that changing pedagogies within a class period can not only be seen as a way to present concepts in an alternate format but may also help engage students in subsequent lecture teaching formats.

Acknowledgment

The authors thank Turning Technology for the loan of the class set of personal response devices used in this study; the authors also thank the teachers and students who participated in the study.

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